Survey of Red Sea Urchin Populations in the Becher Bay area, Southern Vancouver Island, British Columbia, 2001

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SURVEY OF RED SEA URCHIN POPULATIONS IN THE BECHER BAY AREA, SOUTHERN VANCOUVER ISLAND, BRITISH COLUMBIA, 2001

by

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ABSTRACT

Tzotzos, D., A. Campbell, and W. C. Hajas. 2003. Survey of Red Sea Urchin Populations in the Becher Bay area, Southern Vancouver Island, British Columbia, 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2631: 15 p.

A survey of red sea urchin populations in the Becher Bay area of Southern Vancouver Island, parts of Pacific Fishery Management (PFM) Area 20, was conducted in November 2001. A total of 30 randomly placed transects were surveyed by SCUBA divers. Estimated mean density was 0.33 urchins per m^2. Estimated mean biomass was 194.6 g/m^2. Overall, 1.4% of the total number of urchins measured were ≤50 mm test diameter (TD), whereas 82.7% were of legal size (≥ 90 mm TD) for the commercial fishery.

Résumé

Tzotzos, D., A. Campbell, and W. C. Hajas. 2003. Survey of Red Sea Urchin Populations in the Becher Bay area, Southern Vancouver Island, British Columbia, 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2631: 15 p.

Un relevé des populations d'oursins rouges de la baie Becher, située au sud de l'île de Vancouver, qui fait partie du secteur d'exploitation des pêcheries du Pacifique 20, a été réalisé en novembre 2001. Des plongeurs autonomes ont effectué ce relevé sur 30 transects placés aléatoirement. La densité moyenne estimée s'élevait à 0,33 oursins par m^2. La biomasse moyenne était estimée à 194,6 g/m^2. Dans l'ensemble, le diamètre du test de 1,4 % du nombre total d'oursins mesurés était ≤ 50 mm, alors que 82,7 % des oursins étaient de taille légale (diamètre du test ≥ 90 mm) pour la pêche commerciale.

INTRODUCTION

Red sea urchin (*Strongylocentrotus franciscanus*) distribution along the Pacific Coast of North America ranges from the southern tip of Baja California to Alaska (Kato and Schroeter 1985). In British Columbia (BC), the red sea urchin is found throughout shallow rocky subtidal habitats (Bernard 1977; Campbell and Harbo 1991). Red sea urchins are commercially harvested for their gonads (roe), which are sold mainly in Japan. Coastal First Nations communities harvest sea urchins as a food fishery. The commercial red sea urchin fishery started in the early 1970's and the total landed value for the 2000-2001 season was $8.4 million (Campbell *et al.* 2001), making the red sea urchin fishery one of the most valuable shellfish fisheries in BC.

The commercial red sea urchin fishery history and management are described in Campbell and Harbo (1991), and Campbell *et al.* (1999a). Currently, several approaches are used in the management of the red sea urchin fishery, including: a minimum commercial harvest size of 90 mm test diameter (TD); a coast-wide quota; individual vessel quotas; and limited licence entry. Quota calculations are based on estimates of urchin density from field surveys, and estimates of urchin bed areas. Density estimates are therefore essential to the assessment and management of the red sea urchin fishery.

Early red sea urchin population surveys were conducted during the 1970's and 1980's by Adkins *et al.* (1981), Breen *et al.* (1976, 1978) and Sloan *et al.* (1987). Since 1993, red sea urchin population surveys have been conducted as a joint effort between the Pacific Urchin Harvesters Association (PUHA), First Nations, and Fisheries and Oceans Canada (DFO) (Jamieson *et al.* 1998a, 1998b, 1998c, 1998d; Bureau *et al.* 2000a, 2000b, 2000c, 2000d; Tzotzos *et al.* 2003a (in press), 2003b (in press), 2003c (in press)).

Fishery managers requested that red sea urchin surveys be conducted to update density and biomass estimates to help determine quotas. The Becher Bay area [parts of Pacific Fishery Management (PFM) Area 20, sub-area 5], Southern Vancouver Island (Figure 1), was selected for survey through discussion between DFO and First Nations. Local First Nations expressed concern over an apparent decrease in urchin abundance which resulted in recent difficulties in harvesting red sea urchins. This was the first red sea urchin broadbrush survey to be conducted along the south-western coast of Vancouver Island, from the Saanich Peninsula to the Tofino area. The objective of this paper was to present detailed survey results and to estimate current red sea urchin biomass in the survey area.

METHODS

SURVEY AREA AND TRANSECT LAYOUT

Survey efforts were concentrated in the Becher Bay area of Southern Vancouver Island. The entire survey was completed in PFM sub-area 20-5. PFM sub-area 20-5 was open to commercial fishing during the 2000-2001 season, as part of quota area 20 (PFM sub-areas 20-4, 20-5, 20-6), with an allocated quota of 48,400 pounds. Survey results will be used in the next

quota estimation paper, and may have an effect on the quota allocated to this PFM sub-area. Transect locations were selected and plotted on a marine chart prior to the survey to avoid biases in the field. All depths have been corrected to chart datum.

Transect layout along the shoreline was done by systematically placing transects along shore with a random starting point. The ArcView GIS system was used to measure the shoreline length (SL) of the survey area. The position of the first transect was determined randomly, subsequent transects were then spaced evenly along the shoreline. Distance between transects was SL/n where n is the number of transects along the shoreline. Since fluctuations in urchin density are unlikely to match the spacing of the transects, the systematic sample may therefore be treated as a random sample of transects (Jamieson and Schwarz 1998). Transects around islets were plotted by randomly choosing islets and then assigning a random compass bearing to determine the position and direction for each of the transects off an islet.

SURVEY LOGISTICS

The survey was conducted between November 13 and November 15, 2000, on the "Optimist", a privately owned vessel. A crew of five people, consisting of four divers and a boat tender was used for the survey. The vessel docked at the Sooke Marina each night, and travelled to the survey area each day.

DIVE SURVEY METHODS

Leadline transects were laid perpendicular to shore from the boat. Transects were laid out from shallow water to a depth of 15 m, so transect length was dependent on the slope of the substrate. A float was attached to the deep end of each transect. A two diver team surveyed each transect from deep to shallow, one diver measured urchins while the other recorded data. A one meter squared (1 m^2) quadrat was placed on the bottom beside the transect and the test diameter (TD) of each red urchin present was measured to the nearest millimeter with callipers. The depth, substrate type, types of algae (and percent cover), and numbers of abalone (*Haliotis kamtschatkana*), green (*Strongylocentrotus droebachiensis*) and purple (*Strongylocentrotus purpuratus*) sea urchins present in the quadrat were also recorded. The quadrat was then moved 2 m forward along the transect and the process was repeated, so that every second meter of the transect was surveyed. In cases where the substrate was sand/mud and no urchins were found at the deep end of transects, observations of depth, substrate and algae were recorded only every 20 m to minimize dive time. Skipped quadrats were assigned zero values for urchin counts before data were analysed. Once urchins were encountered, sampling was conducted every 2 m until the intertidal zone or the surface was reached. In some quadrats, not all urchins could be measured, so the number of urchins measured on a transect could therefore be smaller than the number of urchins counted.

ESTIMATION OF DENSITY AND BIOMASS

Density and biomass estimates were calculated from the randomly placed transects which were located in red sea urchin beds recorded from 1997 to 2000. The process involved in defining the commercially harvested urchin beds is described by Campbell *et al.* (2001).

Density and biomass were estimated for urchins of 2 size groups: a) all sizes; and, b) for urchins of legal size for the commercial fishery (≥90 mm TD). Estimates of mean density and biomass, per PFM sub-area, were calculated using the equations below.

Density estimates (d_{ts}) in numbers per meter squared for each transect (t) and size group (s) were calculated as:

$$d_{ts} = \frac{N_{ct}}{a_t} * \frac{N_{mts}}{N_{mt}}$$

where N_{ct} is the total number of urchins counted on transect t, N_{mts} is the number of urchins measured in size group s on transect t, N_{mt} is the total number of urchins measured on transect t, and a_t is the surface area of all quadrats surveyed on the transect t. Here a_t is equal to the number of all quadrats surveyed on the transect since each quadrat had a surface area of 1 m^2.

Overall mean density ($\bar{d}_s$) for a PFM sub-area for urchins of size group s was estimated as:

$$\bar{d}_s = \frac{\sum_t (d_{ts} * L_t)}{\sum_t L_t}$$

where L_t is the length of transect t (Campbell *et al.* 1999b).

The standard error ($s_{\bar{d}}$) of estimated mean density was calculated as:

$$s_{\bar{d}} = \sqrt{1 - \frac{n}{T}} * \sqrt{\frac{\sum_t (d_{ts} * L_t - \bar{d}_s * L_t)^2}{n * (n-1) * \bar{L}^2}}$$

where n is the number of transects surveyed, T is the total possible number of transects that can be sampled in a surveyed PFM sub-area and mean transect length ($\bar{L}$) was calculated as:

$$\bar{L} = \frac{\sum_t L_t}{n}$$ (Campbell *et al.* 1999b)

The expression $\sqrt{(1-(n/T))}$ was approximately equal to 1 since n was much smaller than T.

To calculate biomass, the weight of each urchin measured was calculated using the relationship between urchin weight (W) in grams and test diameter (TD) in millimetres (Campbell *et al.* 1999b, 2000a).

$$W = 0.0012659 * TD^{2.7068} \quad n = 167, r^2 = 0.960$$

Biomass density (b_{ts} in grams per meter squared) of urchins of size group s, on a transect t, was estimated using a simplified form of the formula used in previous papers

(Campbell *et al.* 2000a). The formula was modified by Campbell *et al.* (1999b) to simplify computations:

$$b_{ts} = \frac{N_{ct}}{N_{mt}} * \frac{\sum W_{ts}}{a_t}$$

where ΣW_{ts} is the sum of the weights of urchins measured in size group s on transect t and a_t is the surface area of quadrats surveyed on the transect t.

Overall estimated mean biomass ($\overline{b}_s$) per surface area (grams per meter squared) was calculated for each PFM sub-area as:

$$\overline{b_s} = \frac{\sum_t (b_{ts} * L_t)}{\sum_t L_t}$$ (Campbell *et al.* 1999b)

The standard error of estimated mean biomass was calculated using the same formula used for standard errors of density, but d_{ts} and $\overline{d}_s$ were substituted for b_{ts} and $\overline{b}_s$, respectively.

Recruitment estimates for the red sea urchin in BC have generally been expressed as the proportion of the total number of red sea urchins measured that were ≤50 mm TD (R_T; Adkins *et al.* 1981; Breen *et al.* 1976, 1978; Jamieson *et al.* 1998b, 1998c, 1998d; Sloan *et al.* 1987). We used the same method for comparison purposes. We also calculated recruitment as the percent of the total number of sublegal red sea urchins (<90 mm TD) that were ≤50 mm TD (R_S). This method may provide a less biased measure of recruitment in areas where a commercial fishery has taken place, since the numbers of sea urchins ≥90 mm TD would be reduced due to the harvest (Tegner and Dayton 1981).

RESULTS

SURVEY LOGISTICS

A total of 30 transects were surveyed in three days (Table 1, Figure 1). Out of a total 210 counted, 208 red sea urchins were measured in 935 quadrats on the 30 transects. Total transect length surveyed was 1841 m, for an average transect length of 61 m. Seventeen transects were located in the commercial red sea urchin beds recorded from 1997 to 2000 (Table 1).

All transects surveyed were in PFM sub-area 20-5. The transects were spread throughout the Becher Bay area, as far east as Christopher Point, and as far west as Alldridge Point. Given that the survey area constituted only a small portion of the total shoreline and water surface area (between 0 and 10 m below chart datum) of PFM sub-area 20-5, the density and biomass estimates obtained may not be representative of the whole PFM sub-area.

SUBSTRATE AND HABITAT

Generally, the survey area was characterised by steep rocky slopes at the water's edge, with more gradual slopes of mud/shell bottom from approximately 4 m depth, extending to below the maximum surveyed depth of 10 m. The most common substrate was mud, which was the primary substrate in 48.4% of surveyed quadrats. Rocky substrates were the primary substrate types in 40.9% of quadrats, and sand/shell were the primary substrate types in 10.7% of quadrats.

Transects 5 to 11 (Figure 1), were characterised by mainly mud substrate and reduced water movement due to the protected nature of this portion of the bay. The region of Becher Bay between transects 5 to 11 was not suitable habitat for red sea urchins (no urchins were observed on these transects). Transects 5 to 11, inclusive, were not included in the density and biomass estimate calculations.

In general, the transects located in areas with lower exposure to water movement had fewer red sea urchins than transects in areas with greater exposure. In all but one case, urchins were only observed on transects with an exposure value of 8 (high exposure; Table 2, Figure 2). Generally, transects 5 to 11 had higher mean substrate values than the rest of the transects, reflecting the predominance of mud/shell bottom (Table 2). Transects 5 to 11 also had lower mean percent coverage by all four algae types (canopy, understorey, turf, and encrusting). The highest mean densities of red sea urchins were found in the deepest quadrats with rocky substrate, high exposure, and high percent cover by encrusting and understorey algae (Table 2).

Nearly half of the counted urchins were observed on transects around Frazer Island (Table 1, Figure 1). The 0 to 10 m depth zone along the southern side of the island is characterized by rocky crevices running perpendicular to the shore of the island. Drifting algae tends to accumulate in crevices like these. Portions of transect 15 ran parallel to one such crevice with high densities of red sea urchins.

SIZE FREQUENCY DISTRIBUTIONS

The overall mean size of red sea urchins measured was 118.1 mm TD (Table 3). The smallest and largest urchins measured were 33 mm and 180 mm TD, respectively. The overall percent of legal sized urchins (≥90 mm TD) was 82.7%, whereas the overall percent of urchins ≤50 mm TD was 1.4% (R_T). Of the sublegal urchins, the portion that were ≤50 mm TD (R_S) was 8.3% (Table 3).

DENSITY AND BIOMASS ESTIMATES

The estimated mean density of urchins of all sizes was 0.33 urchins per m^2, and 0.27 urchins per m^2 for legal sized urchins (Table 4). The estimated mean biomass of red sea urchins of all sizes was 194.6 g/m^2, and 186.9 g/m^2 for legal sized urchins (Table 4).

DISCUSSION

Red sea urchin populations often have low recruitment (Bernard 1977; Sloan *et al.* 1987), an observation that is supported by this survey. The size frequency distribution of red sea urchins from the current survey indicated a low recruitment of R_T=1.4%, R_S=8.3% (Table 3, Figure 3). Recruitment levels (R_T) reported for southern BC were variable and ranged from 0 to 27% (Adkins *et al.* 1981; Breen *et al.* 1976, 1978; Sloan *et al.* 1987). The Tofino area survey conducted in 2000 showed a recruitment level of R_T=12.5% and R_S=23.5% (Tzotzos *et al.* 2003b (in press)).

The high variability in recruitment levels within an area may be caused by many factors including predation on larvae and juveniles, interactions between juveniles and conspecific adults, and physical and oceanographic characteristics of the region (Kalvass 1992; Sloan *et al.* 1987). The specific factors which influence recruitment in the Becher Bay area are difficult to determine.

The percentage of legal sized urchins (≥90 mm TD) in the present survey was 82.7% (Table 3), higher than the 46.7% observed during the 2000 Tofino survey (Tzotzos *et al.* 2003b (in press)). The proportion of legal sized urchins ranged from 46.6% to 83.9% for the other surveys conducted in 2001 (Tzotzos and Campbell unpublished data).

The area covered by the current survey had not been surveyed before, therefore, no previous data are available for direct comparison of recruitment levels and estimates of urchin density and biomass.

Density and biomass estimates from the current survey (0.33 urchins per m^2, 194.6 g/m^2) were among the lowest reported from surveys conducted between 1997 and 2001. The Tofino survey conducted in 2000 showed an overall red sea urchin density of 2.39 urchins per m^2, and an overall mean biomass of 621.9 g/m^2 (Tzotzos *et al.* 2003b (in press)).

The absence of urchins on transects 5 through 11 is due mainly to the oceanographic characteristics of that portion of Becher Bay. The reduced water movement has resulted in a substrate consisting mainly of mud and debris. This type of substrate is not suitable for many types of algae. Red sea urchins tend to be found in areas with moderate to high exposure to water movement. The higher percent algae cover on transects with greater exposure provides a greater selection and abundance of food sources for red sea urchins, resulting in higher urchin densities.

Red sea urchins in the Becher Bay area exhibit a patchy distribution, consisting of small, dense aggregations found at sites with moderate to high exposure to water movement and algae cover. The low recruitment levels observed may make these clusters sensitive to harvesting pressures. Periodic surveys of the Becher Bay area are recommended to monitor red sea urchin populations.

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Table 1. Summary of transects surveyed during the 13-15 November, 2001 red sea urchin (RSU) population survey in the Becher Bay area of Southern Vancouver Island. Transect lengths in meters, density in number per meter squared, and biomass in grams per meter squared. PFM = Pacific Fishery Management. Depths have been corrected to chart datum. Check marks (✓) indicate transect lying within a known commercial RSU bed.

Transect	PFM Sub-Area	Depth (m) Minimum	Depth (m) Maximum	Time Start	Time End	Total Time (minutes)	Transect Length	Number Quadrats	Number RSU Counted	RSU Density	RSU Biomass	In Bed
1	20-5	0.88	9.72	13:15	13:30	15	87	44	0	0.00	0.0	✓
2	20-5	2.19	4.91	13:44	13:57	13	115	58	0	0.00	0.0	
3	20-5	0.15	8.05	14:10	14:22	12	19	10	22	2.20	1525.8	✓
4	20-5	0.85	9.05	14:32	14:40	8	127	64	0	0.00	0.0	✓
5	20-5	0.52	3.57	12:00	12:10	10	91	46	0	0.00	0.0	
6	20-5	2.10	5.46	11:38	11:46	8	77	39	0	0.00	0.0	
7	20-5	0.00	9.78	11:21	11:28	7	31	16	0	0.00	0.0	
8	20-5	2.83	9.88	10:58	11:09	11	61	31	0	0.00	0.0	
9	20-5	0.79	9.05	10:39	10:45	6	61	31	0	0.00	0.0	
10	20-5	0.00	9.75	10:20	10:25	5	41	21	0	0.00	0.0	
11	20-5	3.05	6.68	14:53	15:00	7	70	36	0	0.00	0.0	
12	20-5	0.03	8.32	9:50	10:00	10	101	51	0	0.00	0.0	✓
13	20-5	-0.03	9.75	10:05	10:15	10	21	11	18	1.64	1273.5	✓
14	20-5	-0.70	10.00	10:20	10:25	5	45	23	0	0.00	0.0	✓
15	20-5	0.09	9.94	10:35	11:00	25	69	35	15	0.43	218.8	✓
16	20-5	0.00	9.81	11:15	11:30	15	65	33	25	0.76	424.0	✓
17	20-5	-0.03	10.36	11:40	11:55	15	31	16	36	2.25	1168.0	✓
18	20-5	0.49	10.42	14:10	14:40	30	43	22	29	1.32	651.0	
19	20-5	-0.91	9.69	13:42	13:57	15	67	34	0	0.00	0.0	
20	20-5	0.49	9.88	13:11	13:31	20	33	17	3	0.18	137.9	
21	20-5	0.55	9.69	12:46	13:01	15	27	14	6	0.43	260.1	✓
22	20-5	0.70	10.39	12:24	13:00	36	41	21	22	1.05	379.6	✓
23	20-5	0.94	8.60	11:40	11:55	15	169	85	5	0.06	41.6	✓
24	20-5	0.06	10.49	11:05	11:25	20	21	11	4	0.36	114.7	✓
25	20-5	1.04	9.05	9:44	10:02	18	29	14	4	0.29	152.3	
26	20-5	1.49	10.36	9:25	9:35	10	15	8	9	1.13	931.4	✓
27	20-5	0.12	11.46	10:40	10:55	15	23	12	12	1.00	737.1	✓
28	20-5	0.82	10.00	10:15	10:25	10	107	54	0	0.00	0.0	
29	20-5	-0.61	10.09	9:55	10:05	10	101	51	0	0.00	0.0	✓
30	20-5	0.40	10.18	9:30	9:40	10	53	27	0	0.00	0.0	✓

Table 2. Mean percent cover by algae, substrate type, exposure, and number of red sea urchins for each depth category surveyed during the 2001 survey conducted in the Becher Bay area of Southern Vancouver Island. Depth category ranges (corrected to chart datum): 1 = <0.0m; 2 = 0.0 to 2.4m; 3 = 2.5 to 4.9m; 4 = 5.0 to 7.4m; 5 = 7.5 to 9.9m; 6 = 10.0 to 12.4m; 7 = >12.5m. Exposure values: 1=minimal sea movement; 2=well sheltered; 3=occasional current; 4=moderate exposure; 5=strong tidal flow; 6=high tide surge only; 7=ground swell normal; 8=high exposure. Substrate values: 1=rock; 2=sand; 3=mud. Canopy = tall, shading, surface-reaching algae. Understorey = 30cm to 2m in height. Turf = 5cm to 30cm in height. Encrusting = species forming a thin, crusty layer on rocks.

Depth Category	Median Depth (m)	Mean Number of RSU per Quadrat	Mean Substrate Category	Mean Exposure	Mean Percent Cover by Algae			
					Canopy	Understorey	Turf	Encrusting
Transects 5 to 11:								
2	1.25	0	1.27	2.55	0.00	20.91	8.41	47.73
3	3.75	0	2.56	2.65	0.00	7.52	9.66	15.93
4	6.25	0	2.46	2.39	0.00	8.54	0.24	20.49
5	8.75	0	2.77	2.18	0.00	3.64	0.23	7.95
All Other Transects:								
1	-1.25	0.00	1.00	7.43	6.43	48.57	8.57	61.43
2	1.25	0.14	1.31	6.57	5.00	31.96	25.66	58.33
3	3.75	0.11	1.96	6.78	1.04	13.58	12.47	33.42
4	6.25	0.31	1.85	7.29	2.63	25.94	7.74	40.17
5	8.75	0.37	2.41	7.57	0.70	9.28	2.13	18.60
6	11.25	2.29	1.53	8.00	1.76	15.59	0.71	55.29

Table 3. Number of red sea urchins measured, and percent of urchins ≤50 mm TD and ≥90 mm TD for each Pacific Fishery Management (PFM) sub-area surveyed in the 2001 population survey in the Becher Bay area. R_T = percent of urchins of all sizes that were ≤50 mm TD. R_S = percent of sublegal urchins that were ≤50 mm TD.

PFM Sub-Area	Test Diameter (mm)			Numbers Measured			Percent of Total Urchins Measured		
							≤50 mm TD		
	Mean	Minimum	Maximum	Total	≤50 mm TD	≥90 mm TD	R_T	R_S	≥90 mm TD
20-5	118.1	33	180	208	3	172	1.4	8.3	82.7

Table 4. Estimates of density and biomass of red sea urchins (RSU), in Pacific Fishery Management sub-area 20-5, for the 2001 survey in the Becher Bay area, Southern Vancouver Island. Estimates are for transects within red sea urchin beds recorded between 1997-2000, for transects outside the beds, and for all transects combined.

Transects Used	Number of Transects	Sum of Transect Lengths (m)	Mean Density RSU/m^2		Standard Error of Mean Density		Mean Biomass of RSU g/m^2		Standard Error of Mean Biomass	
			All Sizes	≥90mm	All Sizes	≥90mm	All Sizes	≥90mm	All Sizes	≥90mm
Within Beds	17	1015	0.33	0.27	0.12	0.10	194.6	186.9	72.9	70.3
Outside Beds	6	394	0.18	0.15	0.16	0.13	99.1	95.7	86.0	82.5
All	23	1409	0.29	0.24	0.10	0.08	167.9	161.4	56.3	54.3

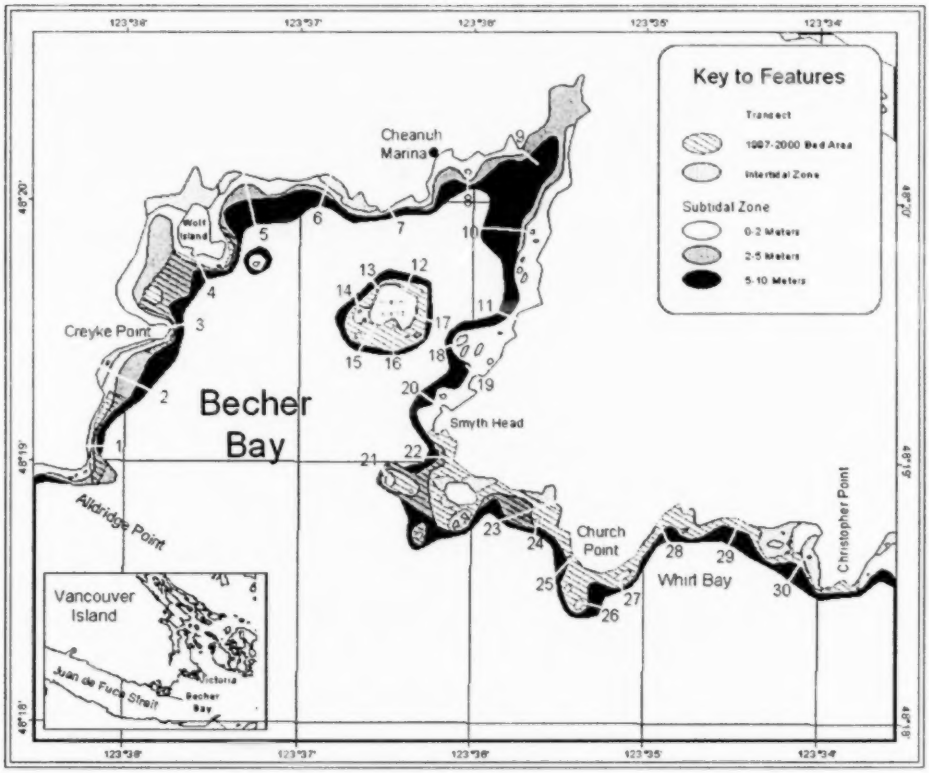

Figure 1. Map of survey area and transect locations for the 2001 red sea urchin population survey conducted in the Becher Bay area of Southern Vancouver Island. Numbers identify transects.

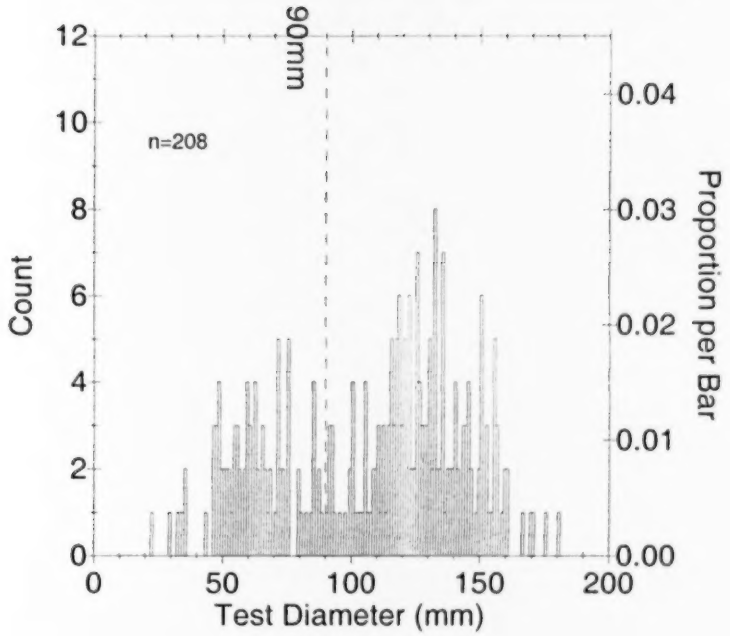

Figure 2. Size frequency distribution of red sea urchins measured on all transects during the 2001 survey in the Becher Bay area of Southern Vancouver Island (n=208). All transects were located within PFM sub-area 20-5. The dashed vertical line represents the 90 mm legal commercial size limit.

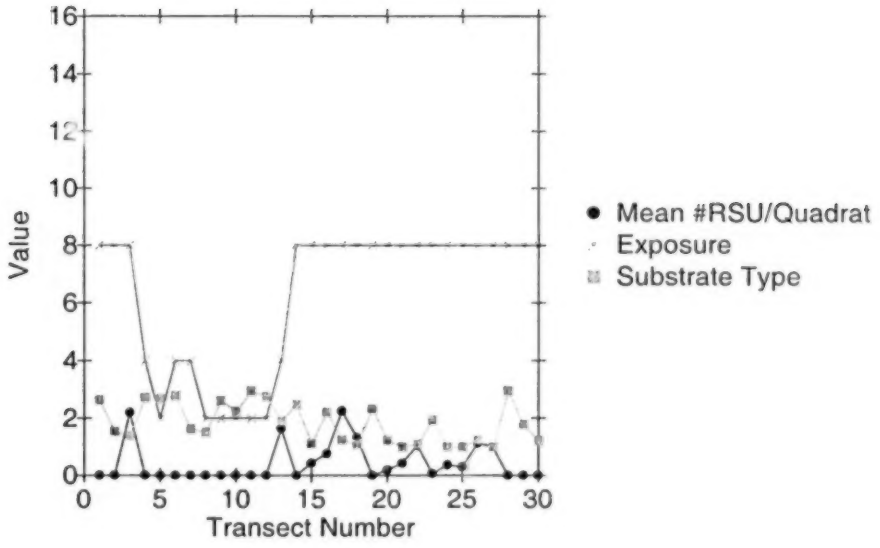

Figure 3. Mean number of red sea urchins per quadrat, exposure values, and mean substrate type for each transect surveyed during the 2001 Becher Bay red sea urchin population survey. Exposure values: 1=minimal sea movement; 2=well sheltered; 3=occasional current; 4=moderate exposure; 5=strong tidal flow; 6=high tide surge only; 7=ground swell normal; 8=high exposure. Substrate values: 1=rock; 2=sand; 3=mud.